FINER POINTS

1946 60th ANNIVERSARY 2006
INDUSTRIAL DIAMOND ASSOCIATION OF AMERICA, INC.

"The ONLY magazine dedicated solely to the technology and application of superabrasives."

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Stir Friction Welding

Calendar of Events

cBN-TiN Composite Coating on Carbide Inserts for Turning Hardened Steel

2007 IDA Annual Meeting

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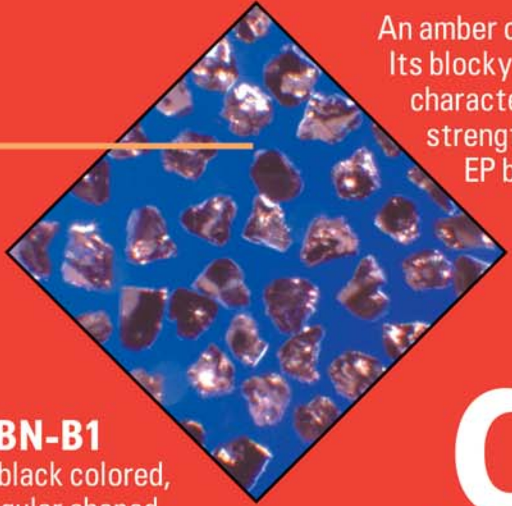

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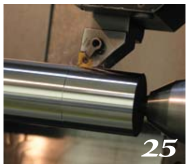
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COVER PHOTO

Photo courtesy of Smith MegaDiamond and shows the Friction Stir Welding application with a superabrasive Polycrystalline pin.

FINER POINTS is the only publication devoted exclusively to the understanding, selection and application of diamond, cubic boron nitride and related materials. It is edited for recipients who are involved in some way with these "superabrasives", either as providers of the materials, producers of products containing the materials or users of these products (e.g., grinding wheels, dressing tools, drill bits, saw blades, sawing wires, cutting tools, polishing compounds, CVD film products, etc.).

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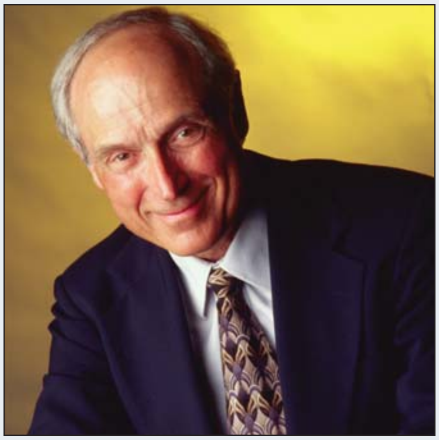
A Finer Point of View…

Greetings of the holiday season 2006

At this time of the year we have excitement, joy and good charitable feelings toward others in our home and offices in anticipation of the Holidays and the New Year. We are often asked, how much of these extends into our business life for even a moment or into the New Year. The Industrial Diamond Association of America was founded by individuals who maintained their good feelings and camaraderie toward each other throughout the whole year. Over the years, as the Association grew, larger firms joined, but the feeling of togetherness was never lost, even in the face of corporate competition. The Association evolved, the Industry evolved and the knowledge about our products evolved. The Association and its members stood up to the many challenges of environmentally clean as well as safe and healthy products (sludge disposal, cobalt reduction and elimination of shattering from high speed wheels as a few examples). The transition to the use of diamond and cBN superabrasives resulted in lower energy consumption, higher yields and higher precision parts which in turn reduces cost and fossil fuel consumption/ greenhouse gas emissions and so forth.



PRESIDENT
Robert Linares

You may not think about your job as extending your holiday feelings into your job and your industry. I think it is evident that you all do it. For more information or help on improved products, education or regulatory processes contact the IDA. We will help your next year be joyous too.

Sincerely,

Robert Linares

Robert Linares, President
Industrial Diamond Association of America

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NEWS *and* notes

IN MEMORIAM – Robert E. Reid

Robert E. Reid, former President of Engis Corporation, passed away October 22nd in Chicago after a short illness. Bob was born in Chicago in 1919; his family moved to Texas while he was still a young boy and he went on to attend the University of Texas in Austin as well as serving in the US Army. During his time in the Army he graduated from the Air Corps School of Aviation Medicine as a flight surgeon's assistant. He also went on to complete Officer Candidate School Medical Admin Corps in 1944. Bob joined Engis Corporation in March of 1954 and was named President of Engis in 1971. He had the vision to lead the company into the international market establishing Engis companies in Japan, Korea, Hong Kong, Singapore, UK and Canada. Bob was always proud of the fact that he served the diamond industry as President of the IDA (1976) and that he was recognized for his service to the industry with an Honorary Lifetime Membership in the IDA in 2003. Bob will be dearly missed and remembered fondly by all of us who knew him as a determined and skilled coworker who always had the best interest of Engis foremost in his mind. He was a dear friend to many and we will miss the support and encouragement that he so freely shared.

IN MEMORIAM – J. Peter Lunzer

The diamond industry was informed of the sudden passing of J. Peter Lunzer on Sunday, November 26, 2006. Peter was the President of Lunzer Inc., and was a well-respected member of the Industrial Diamond Association of America for many years and he was honored with an Honorary Lifetime Membership in the IDA. Peter always was willing to share his views and offer suggestions for the betterment of the industry. He will be missed by all of his friends and colleagues.

2007 IDA ANNUAL MEETING CHANGED

Due to a number of requests from our members and as a courtesy to the Diamond at Work Conference scheduled the week before, the IDA Board of Directors voted to move the IDA Annual Meeting to May 14-15-16, 2007. The IDA Meeting will still be held at the Aladdin Resort & Casino (newly renovated to Planet Hollywood) in Las Vegas. There will be outstanding presentations and important discussions on standards, The Kimberley Process, global economic review and projections, training courses, INTERTECH 2008 and other IDA programs and projects to better serve our membership. We want and need EVERYONE to attend this meeting. Together we are an influential force for change and guidance within the industrial diamond industry and your participation is important.

FORT LAUDERDALE, FLORIDA – WORLDWIDE SUPERABRASIVES LLC,

A leading provider of high quality superabrasive grinding products is pleased to announce that it has recently completed its first website. The website provides users with the ability to match their grinding requirements with the best possible superabrasive product for their respective application. The new website includes comprehensive product descriptions and detailed product photos that will assist end users when deciding which Worldwide product to utilize in their superabrasive tools. Worldwide's new website can be found at www.worldwidesa.com

RICH LADD JOINS NATIONAL RESEARCH CO.

National Research Company recently announced Richard Ladd has joined their company. Rich has spent over 30 years in the superabrasives industry with a background in the application of synthetic diamond and cbn as well as an extensive background in the design, market development and sales of various PCD, PCBN and synthetic crystal diamond markets. Rich will be serving the Midwest Market.

KMT ACQUIRES TWO AMERICAN COMPANIES

KMT has acquired Robotic Production Technology (RPT), North America's leading robotic trimming solutions provider, as well as H2O Jet Inc., a US-based manufacturer and distributor of pumps, spare parts and components for waterjet equipment including diamond nozzles The total purchase price for both companies is USD 36 million with an additional earn-out of maximum USD 2 million. As a result of the acquisitions, KMT becomes the global leader in robotic waterjet and trimming applications, including waterjet pumps for automotive applications and spare parts market. For additional information: KMT: www.kmtgroup.com , Robotic Production Technology (RPT) Inc.: www.rpt.net and H2O Jet Inc.: www.h2ojetcorp.com

INTERTECH 2008! IT IS NEVER TOO EARLY TO MARK THE DATE ON YOUR CALENDAR!

INTERTECH 2008

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Plans are already underway for *INTERTECH 2008,* the Biennial Global Technical Conference on Diamond, Cubic Boron Nitride and their applications. This will be the fourth INTERTECH conference in the series, continuing in the tradition of the previous conferences. Due to the INTERTECH's popularity and requests from attendees for more frequent conferences, INTERTECH has now become a biennial event! We already have some outstanding events planned to make this not only a rewarding technical experience, but also an enjoyable trip you will remember for quite a while! It's less than two years away, so clear your calendars for the May 19-21, 2008. If you are an IDA Member, you'll want to make plans to come early and participate in the IDA Annual Meeting May 17-18, 2008! Disney's Contemporary Resort rises majestically above the nearby Magic Kingdom Park. From the dramatic art in the main tower with sleek monorails cruising overhead to the casual style and convenience of Garden Rooms looking out over the beach, this is an experience not to be missed. After a day filled with conference participation, attendees can relax and enjoy the spectacular views of Bay Lake, the Magic Kingdom Park and Seven Seas Lagoon. For dining excitement that's ahead of its time, experience the award-winning California Grill, located on the 15th floor. Always available is the best in market-inspired cooking where entrees change seasonally and guests enjoy an on-stage kitchen. This distinctive restaurant also offers a superb selection of fine wines and spirits. You have to experience the water sport activities from watercraft rentals to water-skiing, parasailing or fishing excursions. Maybe your tastes are the Olympiad Health Club and spa Pools or the Racquet Club with 6 clay tennis courts. Of course, for those bringing family, the resort has a playground, beach volleyball along with childcare for ages 4-12.

Watch for details at www.intertechconference.com!!!

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EARLY CALL for PAPERS!

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- Rebuilding
- Materials
  - Thermal Sprays
  - Superalloys

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- Parts Manufacturing
  - Gears
  - Wheels
  - Transmissions
  - Engines
  - Other
  - Materials
    - Metal Matrix Composites
    - Bi-Metals
    - High Tech Ceramics
    - Glass

OTHER MANUFACTURING
- Pumps
- Motors
- Heavy Equipment
- Etc.

ELECTRONICS
- Disc Texturing
- Wafer Mfg.
- Polishing
- Optic Windows
- Semiconductors

EMERGING TECHNOLOGY
- CVD
- New Crystals
- Coatings
- Other

MACHINE TOOLS
- Development
- Innovations
- Advancements
- Superabrasive Adaption

MEDICAL
- Surgical Knives
- Prosthesis Fabrication

CONSTRUCTION/ HIGHWAY
- Concrete
  - Aggregates
  - Variables
- Highway/Runway Grinding & Grooving
- Bridge repair
- Renovation
- Block Grinding, Polishing, Application

STONE PROCESSING
- Quarrying
- Sawing
- Polishing
- Materials

MINING/DRILLING/ NATURAL RESOURCE EXPLORATION

OPTICS
- Polishing
- Lens Generation
- Polishing

WIRE DRAWING
- New Technology
- Applications

WOODWORKING
- Hard Woods
- Fiberboard
- Laminates
- Composites
- Film (CVD & PVD)
- Magnetorheological
- Finishing
- ELID etc.

SUPPLIERS TO SUPERABRASIVE INDUSTRY
- Metals
- Coolants
- Measuring & Gauging
- Safety
- Other

RESEARCH AND DEVELOPMENT
- New Crystals/Abrasives
- New Coatings
- Bond Development
- Testing/Gauging
- Tool Fabrication
- Materials
- Tooling
- Application

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INTERTECH 2008! It's coming! The biennial INTERTECH promises to be the most comprehensive commercial and technical conference ever held for industrial diamond, cubic boron nitride, polycrystallines, CVD and other related superabrasives! Leading experts from industry will be there, presenting papers on subjects that will improve performance, increase productivity and reduce manufacturing costs. This will be an international "meeting of the minds" on new technology and applications for grinding, machining, turning, sawing, wire drawing, polishing and literally every other aspect of manufacturing or services. This spectacular event will be held from May 19-21, 2008 in the exciting and entertaining city of Orlando, Florida USA. INTERTECH 2008 will be co-sponsored by the leading global Organizations for this industry - Abrasive Engineering Society, ASM International, Assodiamante, Concrete Cutting Industry Association of Australia, Concrete Sawing & Drilling Association, F.E.P.A., IDA-Americas, IDA-China, IDA-India, IDA-Japan, Japan Society for Abrasive Technology, Society of Manufacturing Engineers (SME) and the Unified Abrasive Manufacturers Association (UAMA). You can be part of this exciting event! We are now soliciting commercial and technical papers of approximately 30 minutes length that address the development of these super-hard materials as well as the dynamics and application of superabrasive systems in the following industries and areas, with a focus on new technology, cutting tools, grinding wheels, machines, wire drawing, innovation, etc., related to PRODUCTIVITY and PERFORMANCE.

On-Line submission of abstracts for ***INTERTECH 2008*** will be available in January 2007 at www.intertechconference.com. If you wish to present a paper, you can also send a one or two paragraph abstract of your paper topic with a copy of this page via E-Mail, FAX or mail to:

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Early consideration for papers is being made at this time. Abstracts are now being accepted; contact us today to be considered. We will respond to all submissions.

Come join us! INTERTECH has the tradition of being the most comprehensive event held on superabrasives!

I propose to present the paper described in the attached abstract at INTERTECH 2008 ... (Please Print Clearly and Include Abstract)

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Let's Hear It For The Good That Diamonds Bring To This World!

By: TERRY M. KANE
Executive Director
Industrial Diamond Association of America

Diamonds should always be a part of the glamour and elegance in our world. What a shame if we cast them all aside with undeserved labels of "Blood or "Conflict". Wouldn't it be a tragedy if the symbol we have always tied to everlasting love and a promise for the future suddenly becomes unfairly shadowed in a realm of deceit and cynicism? Diamond as a perfect gemstone, either natural or synthesized, is a truly wonderful thing, but when we look at the industrial or working side of diamond, it becomes even more spectacular. Diamond can provide medical miracles, electronic innovations and technological breakthroughs at some level for literally every industry. From a diamond-coated prosthesis or diamond knives for eye surgery to diamond used to create computer discs or serve as spacecraft windows, diamond provides many useful services to help mankind. We take for granted the oil and gas used to fuel our cars and heat our homes, but manufactured polycrystalline diamond (PCD) tipped drill bits provide the means to go deeper and faster to recover these critical natural resources. The list goes on and on, from manufacturing wire and automotive components to the generation of glass lenses and vital aerospace parts, diamond is a critical material for industry. In fact, the vast majority of these diamonds are man-made in high-temperature/ high-pressure (HPHT) presses that represent billions of carats in the industry. In a similar manner, tens of thousands of carats of single crystal diamond are produced by both HPHT and Chemical Vapor Deposition (CVD) Diamond processes for industrial and medical use as well as consumer gemstone products.

WHAT IS THE TRUE DIAMOND STORY

Having spent a great deal of time working in the diamond industry, I know the recent reports on the negative aspect of diamonds have been unfair to say the least, disparaging and malicious would be more accurate. Understandably, the true story does not lend itself to the sensationalism intended or invoke the desired distaste or emotional reaction. The public almost never sees the positive side of the diamond industry in these reports. No one denies that for years diamonds funded many terrorist activities in some African countries and these diamonds became synonymous with Blood and Conflict. The truth is, since May of 2000, at the World Diamond Congress in Antwerp, the international diamond industry created the World Diamond Council and announced the industry's zero tolerance policy towards conflict diamonds. The diamond industry has worked to come up with ways to stop the trade in conflict diamonds and to ensure consumers that the diamonds they purchase have not contributed to violent conflict and human rights abuses in their countries of origin. These efforts are not limited only to gem diamonds but include natural industrial diamond as well. The result of their efforts has been the Kimberley Process, which is a joint government, international diamond industry and civil society initiative to stem the flow of conflict diamonds, which are the rough diamonds that are used by rebel movements to finance wars against legitimate governments. The Kimberley Process Certification Scheme is an

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innovative, voluntary system that imposes extensive requirements on Participants to certify that shipments of rough diamonds are free of conflict diamonds. Participant countries or diamond traders that do not comply with the Kimberley Process are breaking the law. For example, The Kimberley Process suspended the Republic of Congo (also known as Congo Brazzaville) in 2004 for failing to demonstrate adequate compliance with Kimberley Process directives. It has since claimed that all internal controls have been attended to and has applied to rejoin the Process. The Chair and various Working Groups of the Kimberley Process are currently reviewing its application. As of November 2006, 71 countries including the European Community that account for approximately 99.8% of the global production of rough diamonds were members of this system which ensures that conflict diamonds are unable to enter the diamond supply and be used to fund conflicts. When any concerns arise regarding a country's adherence to the Kimberley Process, they are investigated and dealt with at an inter-governmental level. Under this system, rough diamonds are sealed in tamper-resistant containers and accompanied by forgery resistant, conflict free certificates with unique serial numbers each time they cross an international border. This means only a very small percentage of rough diamonds could slip though this extensive regulation process. Today, the Kimberley Process Certification Scheme has evolved into an effective mechanism for stopping the trade in conflict diamonds to well below 1%. While this is a significant improvement, it is still not enough. The diamond industry will not rest until conflict diamonds are eradicated completely. The tireless efforts of governments, industry leaders and civil society representatives have helped ensure that the horrors caused by conflict diamonds have been drastically reduced while striving towards a world completely free of conflict diamonds. Recently, the World Trade Organization's (WTO) Council for Trade in Goods agreed in principle to renew its waiver that allows countries to block trade in conflict diamonds until 2012. According to published reports, the decision was made at a meeting on November 20, 2006 and must be formally adopted by the General Council, the WTO's top permanent decision-making body. The original waiver was approved in early 2003 and expires at the end of this year. To comply with KP requirements, meant to track rough diamonds and keep illicit stones out of the legitimate diamond trade, WTO members need recourse for measures that under normal circumstances violate WTO obligations. Specifically, they must be able to discriminate between diamonds based on country of origin and have the ability to ban diamond exports and imports.

MORE THAN 99% OF DIAMONDS TRADED INTERNATIONALLY ARE FROM CONFLICT FREE SOURCES

Decreasing the trade in conflict diamonds in a diamond-producing country minimizes the ability of rebels to fund violence. By allowing only legitimately sourced diamonds to be traded, revenues from these diamonds can then be used to benefit the people of that country. Today, more than 99% of diamonds traded internationally are from conflict free sources. Revenues from these legitimately sourced diamonds contribute significantly to the economies, healthcare systems, education and other infrastructure developments in some of the countries where they are found.

GLOBAL HEALTH, EDUCATION AND QUALITY OF LIFE SUPPORTED BY THE DIAMOND REVENUES

Granted, smuggling diamond for arms, murder and mayhem makes for great articles, news stories and of course, blockbuster movies… but the other side of the story is about responsibility, regulation and positive actions to limit the source and trade of these diamonds. The truth is, diamonds have led to prosperity in many diamond-producing countries and helped boost the economy in many African countries. Revenues from diamonds provide essentials such as schoolbooks and electricity and have enabled governments and health organizations to greatly improve existing public health services and provide new health services to those who have never had them before. Diamond revenues have funded more hospitals and more medical centers ensuring healthcare is extended to millions of people. Diamond-funded health projects extend beyond just building hospitals. Debswana, a mining company in Botswana, recently became the first mining company in the world to extend free treatment to HIV positive employees and families. Diamond revenues enable every child in Botswana to receive free education up to the age of 13. Many African countries do not have sufficient tax revenues to pay for public education, unlike countriesin many other parts of the world. Most African governments therefore need to charge students and their families for education. Botswana, with the help of diamond revenues, is one of the exceptions. When diamonds were discovered in Botswana in 1966, there were only three secondary schools; today, due to revenues from diamonds, there are more than 300. Where children 40 years ago had no access to schooling or received lessons in the open air, they now have classrooms, sports equipment and books. Free schooling starts for children as young as six years old and continues throughout primary education. Even after the age of 13, secondary education is 95% funded by the government, enabling children to stay in school longer. The goal is to improve personal development and literacy rates that will pave the way for future generations. In addition, an estimated 10 million

99% of Diamonds are from Conflict Free Sources

Mines Provide Jobs & Revenue for African Countries

people globally are directly or indirectly supported by the diamond industry. From the countries where they are sourced to the countries where they are polished and sold, diamonds are supporting millions of people globally. In the African country of Namibia, the diamond mining industry is the largest single employer after the government. In Botswana approximately 25% of the labor force is directly or indirectly linked to diamonds. In India approximately one million people are employed in the diamond industry and almost 20% of the total employment in the Canadian Northwest Territories is related to diamond mine operation and construction.

CONFLICT COUNTRIES NOW AT PEACE

Between the years of 1991 and 2002 Sierra Leone descended into a violent civil war. In 2000, the United Nations Security Council banned both direct and indirect imports of rough diamonds from Sierra Leone to member states. Sierra Leone is now at peace and exported approximately $142 million dollars in diamonds last year. When the war ended, Sierra Leone became a democratic country. Since then, the diamond industry has provided technical assistance and training to Sierra Leone's Ministry of Mines in setting up the Government Diamond Office. In 2003 Sierra Leone joined the Kimberley Process, the international agreement developed to prevent conflict diamonds from entering the legitimate diamond supply chain, providing an assurance that diamonds are from conflict free sources. That same year, the United Nations Security Council lifted the regulation regarding the export of diamonds from Sierra Leone. Sierra Leone is now using revenues from diamond exports to rebuild its infrastructure, health services and education systems. According to Alhaji Deen, Sierra Leone Minister of Mineral Resources, "Countries such as Sierra Leone and Angola...need revenue from diamonds if they are ever to recover from conflict and achieve peace. These legitimate diamonds will now help to bring prosperity to the people of Sierra Leone". As additional organizations invest in diamond mining in Sierra Leone, they will continue to help this previously war-torn country make significant strides towards social and economic prosperity.

MAJOR AFRICAN LEADERS SUPPORT DIAMOND INDUSTRY

Over the last few years African leaders have expressed the importance of diamonds to countries in that region. In 1999 Nelson Mandela said, "The diamond industry is vital to the southern African economy." Five years later, the democratically elected President Thabo Mbeki of South Africa was quoted, "We know that diamonds are a valued source of employment, foreign exchange, tax revenue, new investments and play a positive role in enhancing the overall economic well being of countries and

All Diamond Tools Are The Same...

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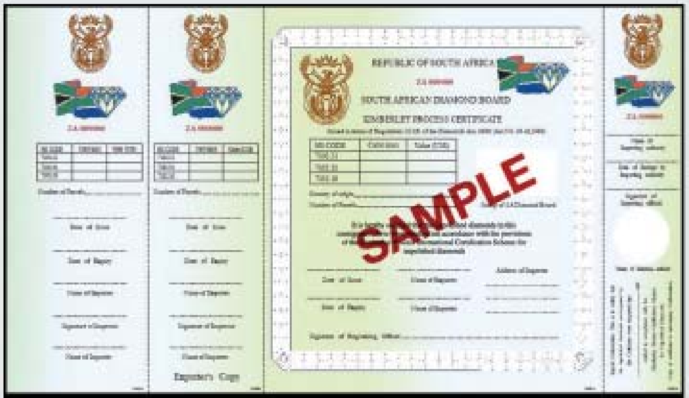
Diamond At Work™

Following the success of the 1st International Industrial Diamond conference in Barcelona, Diamond at Work would once again like to invite leading academic and industrial experts from around the world to share their knowledge of the exciting opportunities for industrial diamond and related materials.

This two day conference will cover the broad spectrum of diamond applications, featuring the latest research developments and highlighting trends in industry. International participation will make this a truly wide ranging event with parallel technical sessions catering for all interests.

We hope to see you in Italy!

More information at **www.diamondatwork.com**



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KIMBERLEY PROCESS CERTIFICATE

SAMPLE

Kimberley Process Certificate

Diamonds Support Millions of People Globally

local communities. This year, Festus Mogae, the democratically elected President of Botswana, said, "For our people, every diamond purchase represents food on the table, better living conditions, better healthcare, potable and safe drinking water, more roads to connect our remote communities and much more." These leaders resounding support of the diamond industry reinforces the positive influence and effect of diamonds in their countries.

SUCCESSFULLY CURTAILING TRADE IN CONFLICT DIAMONDS

The Southern African diamond producing states have successfully come up with ways to stop the trade in conflict diamonds and to ensure consumers that the diamonds that they purchase have not contributed to violent conflict and human rights abuses in their countries of origin. The Kimberley Process imposes stringent requirements on all participating countries to guard against conflict diamonds entering the legitimate trade. Even the United Nations General Assembly has adopted a resolution supporting this creation of an international certification scheme for rough diamonds. In the United States, the Kimberley Process is enforced by the Clean Diamond Trade Act, which requires annual reviews of the standards, practices and procedures of any entity in the US that issues KP certificates for the export of rough diamonds. The diamond industry also implemented a system of self-regulation to support the Kimberley Process, to provide consumers with additional assurances. This voluntary self-regulation covers the entire diamond supply chain, from mine to point of sale (not just rough diamonds), and requires the industry to implement a code of conduct to prevent the buying and selling of conflict diamonds. It also provides for a system of warranties, underpinned through verification by independent auditors of individual companies and supported by internal penalties set by industry, which is designed to help to facilitate the full traceability of rough diamond transactions by government authorities. The bottom line is the majority of all diamond companies within this industry are providing sufficient assurances to consumers that the diamonds they are selling and using are conflict-free.

Diamonds Vital to African Economy

THE TRUE DIAMOND STORY

Critics, no matter who they might be, should present the whole truth and not exploit only the negative side of the entire story. Our diamond industry both in natural gems and industrial has high integrity and is constantly working to ensure that all diamonds we sell can be traced back along the supply chain to non-conflict countries. I recently received a couple press releases and announcements that condemned the Diamond Industry in general and labeled all its leaders and those who profit from diamonds with derogatory names and terms of ill repute. Knowing many people in this industry and their high integrity, I found that characterization to be inappropriate and completely wrong. It is a shame some people and well-meaning organizations continue to write disparagingly about all diamonds in general and misrepresent the Diamond Industry as a whole ◆

Let's hear it for the good that diamonds bring to this world!

Special thanks to Members of the Industrial Diamond Association of America, the World Diamond Council and Cecilia L. Gardner, Esq. President & CEO Jewelers Vigilance Committee for their assistance in researching this editorial. For additional facts on the diamond industry efforts see www.diamondfacts.org. For more information on industrial diamonds visit www.superabrasives.org.

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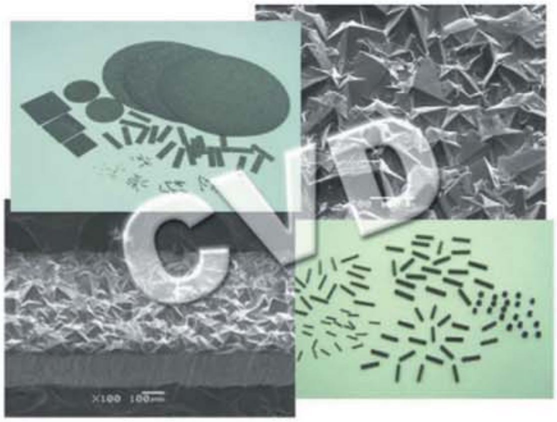

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NEW TECHNOLOGY FOR PRECISE MANUFACTURING A WIDE VARIETY OF DIAMOND CUTTING TOOLS

Carnegie, PA – Vollmer of America Corporation has introduced a new series of wire erosion machines designed specifically for the manufacture of diamond tipped metal cutting tools. The Model QWD 760H incorporates the unique and patented wire erosion technology that has proven to be the most efficient and successful method for removing large volumes of PCD. Completely programmable, the generator can be set for four erosion stages for coarse roughing, roughing, finishing and fine finishing. Settings can be stored and recalled easily to accurately control the amount of erosion required for any stage. This results in consistent surface finishes less than 0.2 microns Ra. *For additional information, contact Vollmer of America Corporation at 412.278.0655 or visit us at www.vollmer-us.com*

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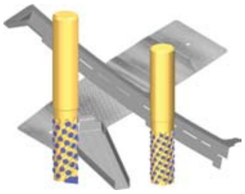

Announces the winner of the AIRTEC - Award 2006 is the multiple cut diamond end mill for the machining of sensitive components made from fiber composite materials for the aerospace and plastic manufacturing industry. The so-called multiple cut-end mill consists of a multiplicity of polycrystalline synthetic diamonds (PCD) which rotate softly and gently, somewhat like a rasp and for that reason are free of chipping without disturbing noise and can effectively machine components of carbon fibers and glass fibers. *For further information see: www.lach-diamond.com.*

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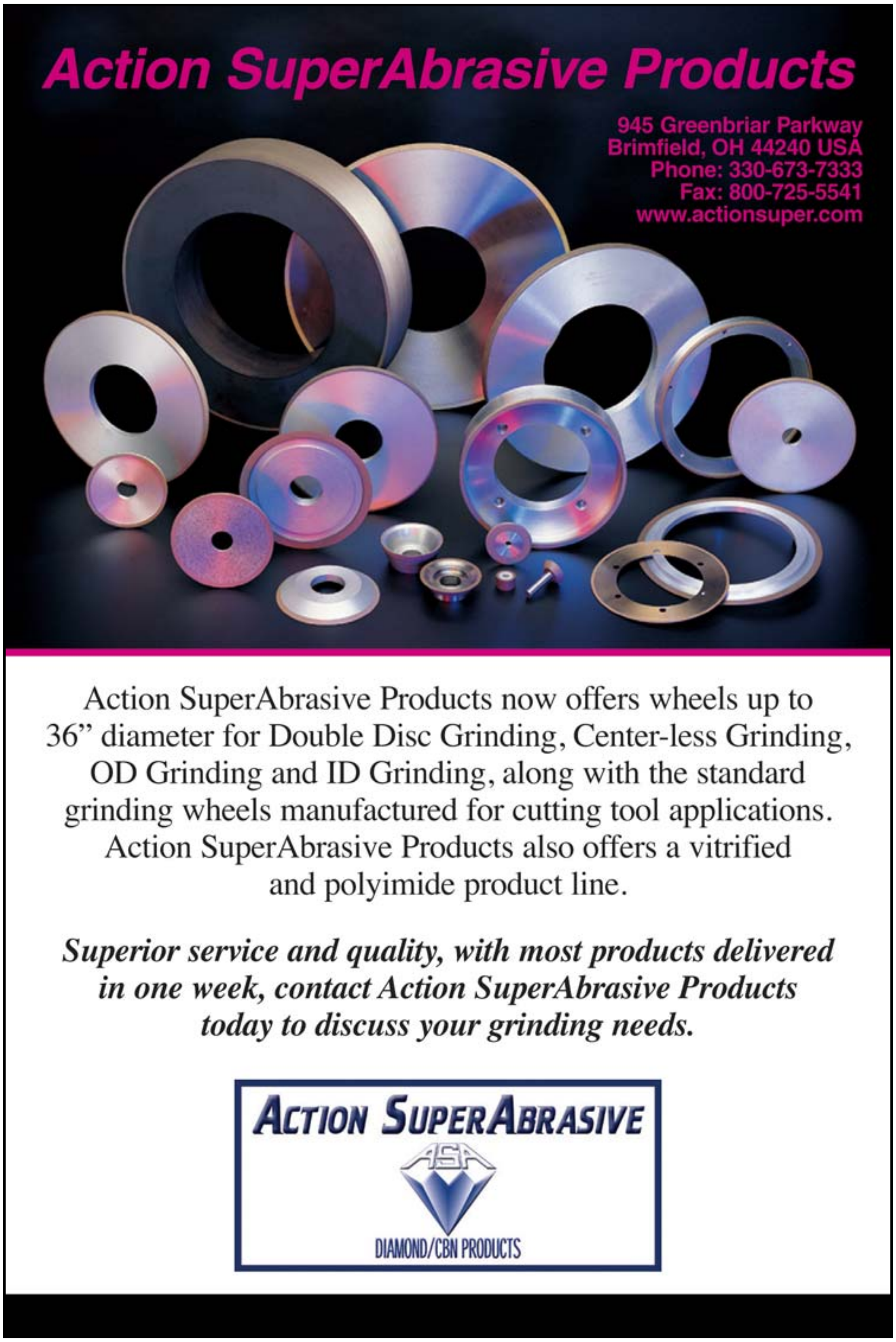

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Spring 2007	Superabrasives Resource Directory	Mar 31, 2006
Summer 2007	New Superabrasive Applications & Products	May 31, 2007
Fall 2007	Drilling & Mining	July 31, 2007
Winter 2007/2008	Industry Review & Highlights	Nov 30, 2007
Spring 2008	INTERTECH 2008 Preview & Superabrasives Resource Directory	Mar 31, 2007

***Editorial topics subject to change**

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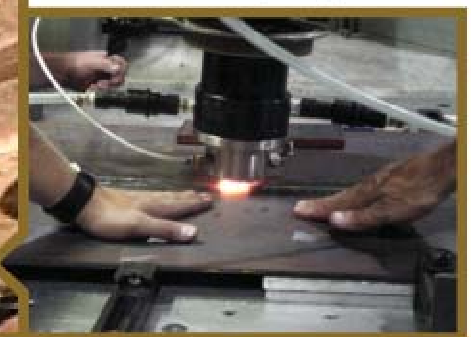
Friction Stir Welding Using Polycrystalline Cubic Boron Nitride And Polycrystalline Diamond For High Melting Temperature Materials



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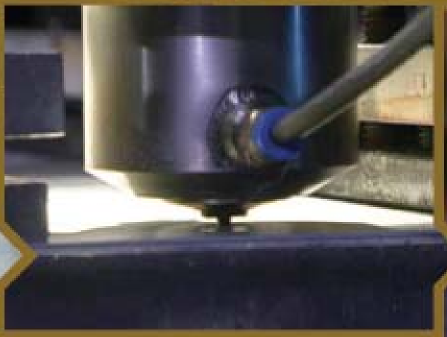


THE FRICTION STIR WELDING PROCESS

Friction stir welding was developed and patented by The Welding Institute (TWI) in England in 1991. FSW is a solid state welding process in which a rotating nonconsumable tool is translated along the interface between two materials to be joined. Though initially developed for low melting temperature alloys, recent development of new tool materials such as polycrystalline cubic boron nitride (PCBN) and polycrystalline diamond (PCD) has expanded the application of FSW into high melting temperature materials such as steels, stainless and duplex stainless steels, nickel base alloys, and abrasive materials such as metal matrix composites (MMC).

The tool consists of a protruding "pin", which is plunged into the work pieces, and a larger concentric "shoulder", which is maintained on the surface of the joint *(Figure 1)*. The shoulder consists of a concave surface, which produces a combination of frictional heating and forging pressure. The process is a solid state joining process in which melting does not occur during the welding process. Welding parameters for FSW consist of the rotational speed of the tool, the forging pressure applied by the tool, and the travel speed of the tool with respect to the base material. These parameters are governed by the tool geometry (i.e. shoulder and pin diameter), mechanical properties of material to be joined (i.e. flow stress), and material thickness. Frictional heating produced by shoulder and pin rotation in contact with base material produces a local plasticized region around the tool. As the tool traverses along the weld joint, plasticized material is displaced around the tool. The high degree of deformation and the large forging pressures applied by the tool shoulder, produce a full metallurgical bond.

FSW NOT SUSCEPTIBLE TO SOLIDIFICATION DEFECTS

As a solid state welding process, FSW is not susceptible to typical solidification defects such as porosity and hot cracking that are common in arc welds. Microstructurally distinct regions are characterized much like those in arc welds. These include: A) the unaffected base material, B) heat affected zone (HAZ), C) thermal mechanically affected zone (TMAZ), and D) the stir zone (SZ), or weld nugget *(Figure 2)*. The SZ consists of fine equiaxed grains.

Recrystallization has occurred in order to relieve the high amount of plastic strain introduced by the FSW process. Adjacent to the SZ are the TMAZ and HAZ regions. The TMAZ is distinguished by an elongated plastically deformed grain structure. Grains in this region have been deformed at an elevated temperature by the formation of the SZ. The HAZ is the region outside of the weld, which has undergone a thermal cycle from the welding process. There is also an advancing and retreating side of the weld associated with FSW. The side of the weld in which the tool rotation and the travel direction is in the same direction is considered the advancing side. The side of the weld in which the tool rotation is opposite of the travel direction is considered the retreating side. Distinct microstructural features are present in these areas depending upon the material being joined, FSW tool geometries, and the welding parameters.

PREVIOUS UNWELDABLE ALLOYS EXHIBIT EXCELLENT MECHANICAL PROPERTIES WITH FSW

Many aluminum alloys previously considered as unweldable have exhibited excellent mechanical properties through FSW. The aerospace industry has aggressively pursued the application of this technology to capitalize on the technical benefits and cost savings.

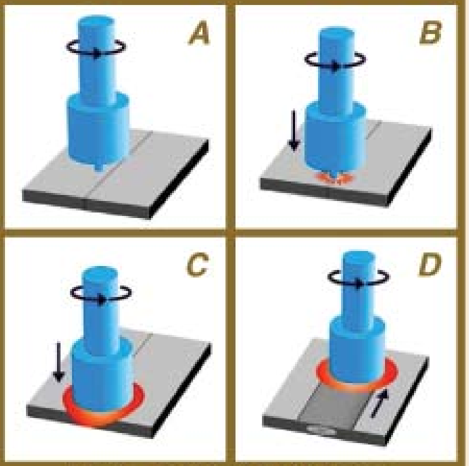


Figure 1 – Schematic of FSW Process

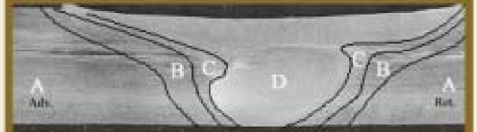
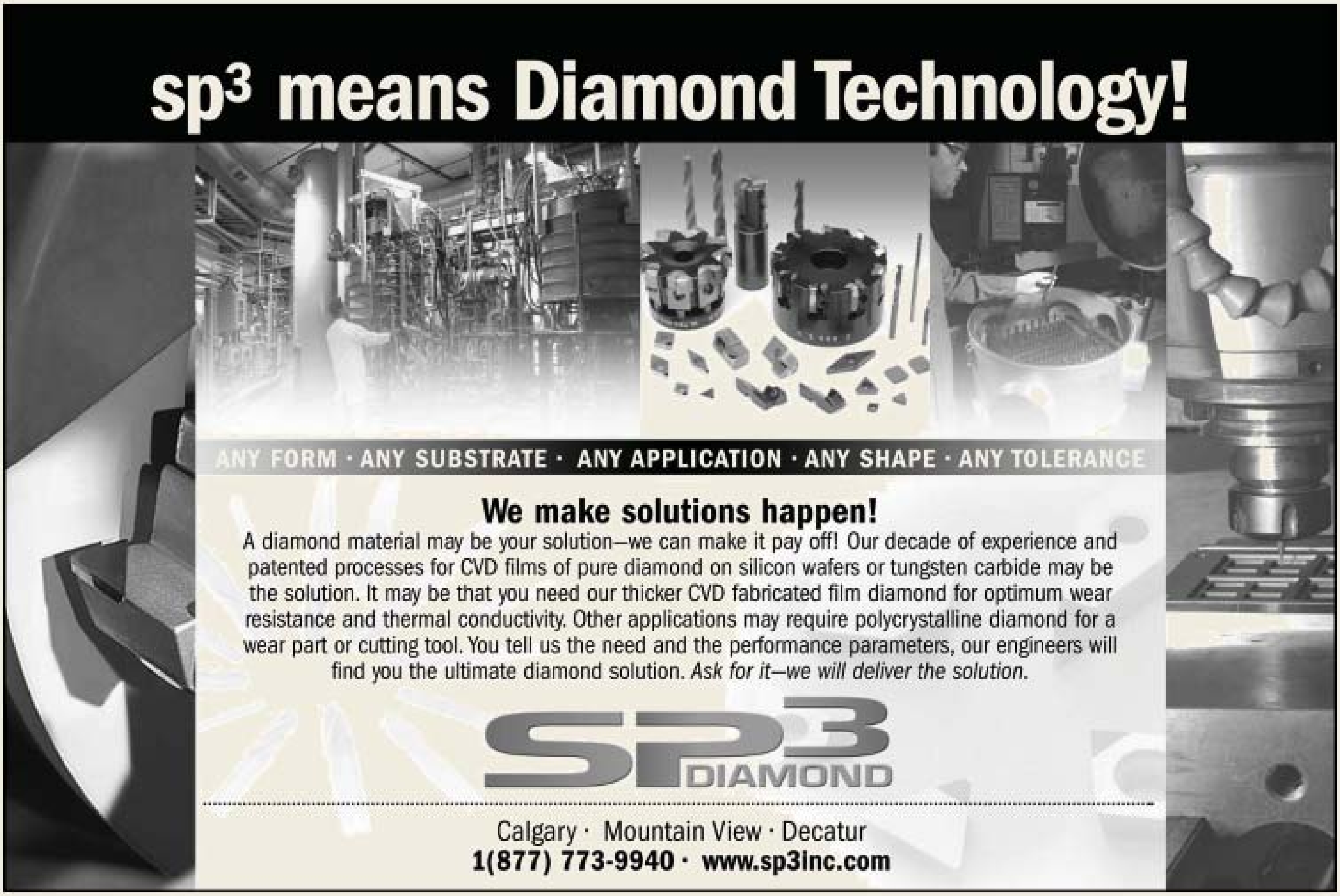


Figure 2 – Transverse macrograph of friction stir welded 2205 duplex stainless steel showing distinct regions A) base metal, B) HAZ, C) TMAZ, and D) SZ.

Recently, the FAA has approved FSW for use on the Eclipse 500 corporate jet, and the Boeing Company has implemented the process in full production on the Delta II and Delta IV commercial launch vehicles. The majority of applications for friction stir welding have been in aluminum alloys, copper, and other softer metals. However, there has been a great deal of interest in and research done in the area of higher melting temperature materials such as steels and stainless steels. Several different tool materials have been tried, such as sintered tungsten carbide, refractory alloys, ceramics, and heat-resistant superalloys, but with very limited success. Successful joining of these higher melting temperature materials has required the development of tool materials with high hot hardness at temperatures in excess of 700°C and good abrasion resistance. Furthermore, the joining of materials having extreme abrasive properties has also been difficult for the FSW process, such as the case in joining metal matrix composites (MMC) having a low melting temperature alloy matrix and an abrasive reinforcement dispersion due to rapid tool wear. These abrasive alloys have also required the development of advanced tool materials having high abrasion resistance.

POLYCRYSTALLINE DIAMOND IN FSW

Polycrystalline Diamond (PCD) has long been recognized as a useful material in applications requiring superior abrasion resistance, such as in oil and gas drilling applications or in the machining industry as a cutting tool material. Due to iron's affinity for carbon, it is not readily used for the machining of ferrous materials.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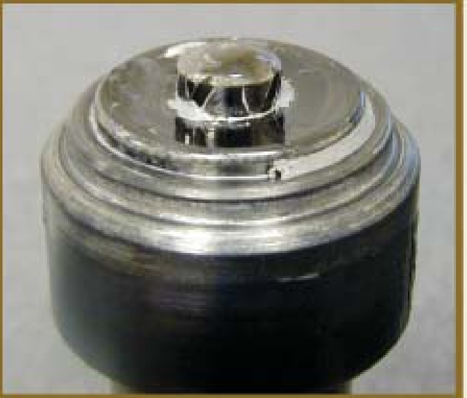
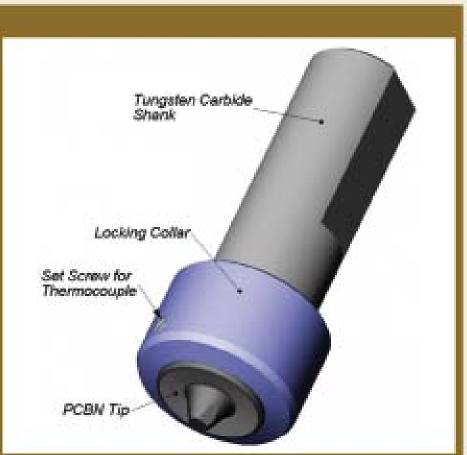


Figure 3 – PCD tool developed for friction stir welding of MMC materials



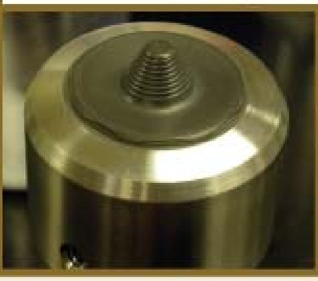


Figure 4 – PCBN tool developed for friction stir welding of steel and stainless steel alloys

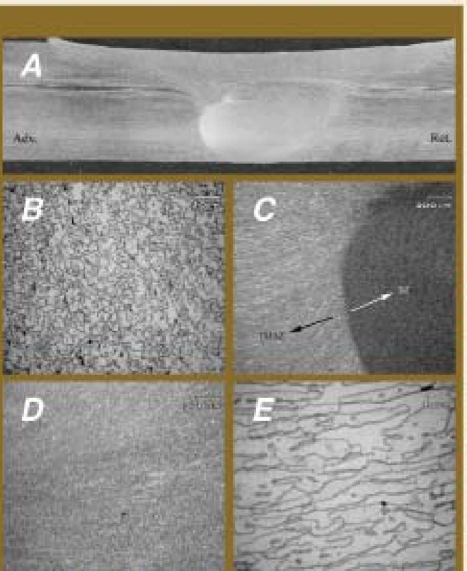


Figure 5 –Microstructure of different weld regions of SAF 2205 friction stir weld; a) transverse macrograph, b) refined grain structure of SZ (1000X), c) advancing side TMAZ region (50X), d) retreating side TMAZ region (50X), and e) base metal grain structure (1000X)

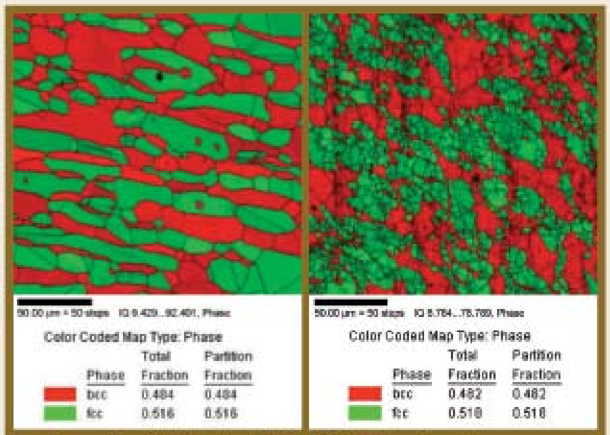
Also, PCD's metastable diamond phase has a reversion temperature of approximately 700°C. These limitations make PCD generally unsuitable for machining ferrous materials are the same that disqualify it for use in FWS applications involving steels and stainless steels. The unique properties of PCD do however provide a solution for joining MMC materials where an aluminum matrix is reinforced with an abrasive reinforcement. A single body FSW tool profile of a shoulder and pin was constructed from PCD and evaluated in MMC materials. One such material tested consisted of a 6061 as aluminum matrix with a 25% boron carbide particulate reinforcement. Excellent welds were produced, and tool wear was not detectable. For thicker section material (> 3 mm) a composite body shoulder and pin was produced using a PCD shoulder, and PCD vein technology for the pin where helical veins of PCD were present in tungsten carbide *(Figure 3)*. For 12-mm thick MMC plate composed of 6061 aluminum with a 25% boron carbide reinforcement, weld tensile properties of 86% were attained using FSW. The carbide dispersion in the weld is maintained compared to the base metal.

POLYCRYSTALLINE CUBIC BORON NITRIDE IN FSW

Polycrystalline cubic boron nitride is an ultrahard material widely used in the machining industry for the cutting of abrasive and hard ferrous alloys. Developed to address diamond's instability in ferrous materials, cubic boron nitride is much less soluble in iron, and is stable up to temperatures of 1200°C. The friction stir welding of high melting temperature alloys (alloys having a higher melting temperature than aluminum) typically requires temperatures greater than 800°C for adequate material flow. For the development of FSW tools utilizing PCBN, a commercially available free-standing high-content grade was first used with promising results in the area of both wear and mechanical strength. This material displayed good wear properties given its high hardness values in the range of 3100 HV. The FSW process does however require higher toughness properties than are typically found in commercial machining grades of PCBN. Recognizing this need for higher toughness tool materials, new grades of PCBN have been developed having material properties engineered more specifically to meet the demands of FSW applications. These grades have a relatively high hardness (2400-2800 HV), but increased toughness over traditional PCBN grades due to high-toughness metallic second-phase binder compositions used. This development work has largely focused on free-standing grades having a metallic second phase sintered at high-temperature/high-pressure pressing conditions Whereas friction stir welding of steel had been deemed essentially impractical with tool materials previously tried, new PCBN tool materials have opened up new possibilities. Tool life has varied depending upon alloys to be joined and welding parameters. Over 80 meters of linear welds have been recorded in A-36 steel having negligible tool wear with tool failure occurring from mechanical fracture. Chemical wear is typically the wear mechanism in austenitic stainless steel alloys. Tool life is quite good in these alloys, however surface features on the tool such as threads or flats.

The grade development work for PCBN FSW tools has also demonstrated that material properties of the PCBN can be engineered to meet the specific demands of various welding applications. Properties that can be influenced include hardness, wear mechanisms, fracture toughness, thermal conductivity and specific heat capacity. These properties are varied by manipulating cBN particle size, cBN concentration, binder composition, and sintering conditions. In addition to engineering the PCBN properties, tool design and tip geometry have been seen to be critical to the overall performance in welding applications.

A wide range of alloys has been successfully friction stir welded using tools fabricated from PCBN. These include ferritic steels, stainless steels, and nickel base alloys. Ferritic steels such as high strength low alloy steels (HSLA) and petroleum pipeline grades ranging from X-65 through X-100 have been successfully joined with excellent results. HSLA 65 has been friction stir welded with tensile properties achieving 98% of the yield strength as compared to the base metal, and a 17% increase in ultimate strength over that of the base metal. Austenitic, duplex, and martensitic stainless steels have also been successfully joined. Duplex stainless steels are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fcc 0.518 0.518

Figure 6 – OIM™ output of SAF 2205 showing phase maps of a) base metal and b) SZ

considered "difficult" to weld alloys using fusion-welding techniques. Friction stir welded alloy 2205 duplex stainless steel has exhibited tensile strengths of 676 MPa and 883 MPa yield and ultimate strengths respectively as compared to that of the base metal of 607 MPa yield and 786 MPa ultimate tensile strength. Grain refinement was exhibited while maintaining a wrought microstructure with equivalent austenite and ferrite *(Figures 5, 6 & 7)*.

Nickel base alloys such as Ni 201, Ni 600, and Ni 718 have also been successfully friction stir welded using PCBN. Ni 718, which is a precipitation hardenable alloy, when friction stir welded in the annealed condition, achieved mechanical properties of 668 MPa and 986 MPa yield and ultimate tensile strengths respectively. Ni 718 in the annealed condition exhibits a yield strength of 462 MPa and an ultimate tensile strength of 896 MPa, as compared to the fully hardened properties of 1172 MPa yield and 1392 MPa ultimate tensile strength. The weld surface of the FSW joint was smooth, and the microstructure of the weld exhibited a refined grain structure *(Figure 8)*.

Research has been conducted in a variety of alloys beyond those listed in this paper. FSW offers optional solutions in joining "difficult" or "unweldable" alloys. Benefits of FSW are also exhibited on typical weldable alloys in the areas of reduced distortion and improved engineering performance.

FRICTION STIR WELDING VIABLE PRODUCTION METHOD WITH EXCELLENT MECHANICAL PROPERTIES

Friction Stir Welding has emerged as a viable production method for welding low melt point metals such as aluminum. Limitations in tool material properties have restricted the application of FSW into areas of interest such as certain difficult to weld steels and abrasive MMC's. FSW tools incorporating ultrahard materials such as PCBN and PCD have demonstrated good performance in welding these materials. It has also been seen that welds produced using FSW have exhibited excellent mechanical properties along with a wrought microstructure as opposed to a cast microstructure created by fusion welding techniques. ■

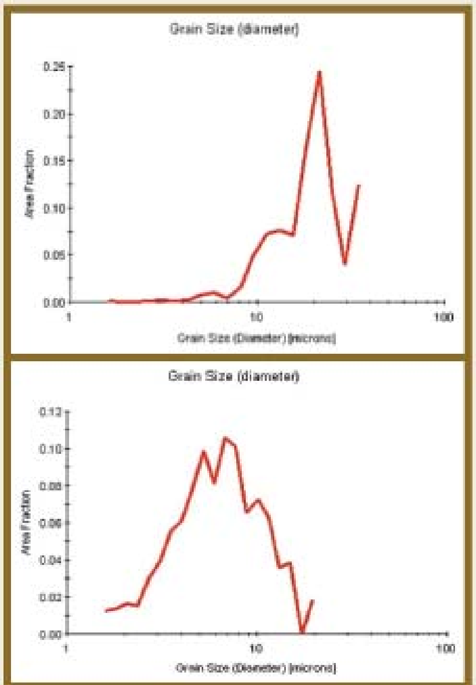

Figure 7 – OIM™ output of SAF 2205 showing grain size charts of the austenite found in a) base metal and b) SZ

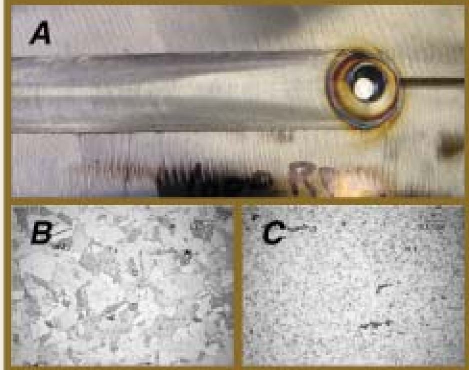

Figure 8 – a) Surface of friction stir welded alloy Ni 718, b) micrograph of Ni 718 base metal (500X), and c) micrograph of stir zone of Ni 718 friction stir weld (500X)

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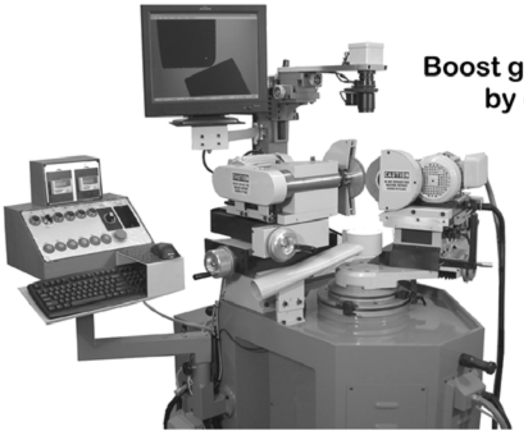

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cBN-TiN Composite Coating on Carbide Inserts for Turning Hardened Steel

By: WENPING JIANG, Chief Engineer and
AJAY P. MALSHE, Chief Technology Officer
NanoMech

HARDER MATERIALS DEMAND BETTER CUTTING TOOLS

The use of ever-harder materials is an ongoing trend in new product development. For example, the use of ceramic materials in tools, machines and other wear resistant components is now a common practice and is increasing at a steady rate with the development of new ceramics with improved toughness. With the ever-increasing use of such hard materials in manufacturing, however, there is a consequent demand for high performance machining (at higher speeds and precision). This demand in turn drives a demand for better cutting tools. Historically, the development of tool materials proceeded from tool steels to cemented carbide and to special ceramics and superhard materials. The cemented carbides, titanium carbide based cermets and alumina based ceramics are adequate cutting tools for many engineering materials. However, in cutting high-alloy steels, hardened steels, chilled cast irons and superalloys, these tools have limited life, and in some cases they are unable to perform adequately. Grinding is often used for finish-machining such materials when high precision is of paramount importance. Nevertheless, grinding is relatively slower (about two times) than its complementary process, hard turning, in terms of productivity. In addition, the machinery and maintenance cost of a grinder is much higher than that of a lathe for hard turning. Hard turning, a process of single-point cutting of materials with hardness above 45 HRC, has experienced significant growth due to the continuous need for improving productivity and decreasing processing cost. Because of its advantages of high geometric flexibility, reduced machining sequences, options for dry machining, improved surface integrity, and significantly enhanced fatigue life, hard turning is a potential alternative to mechanical grinding for small-

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WHAT:

- **Major end users, economists, government agencies and our own members will interact with attendees to help improve business operations, increase profitability and share innovations and technological developments**
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PLANS BEING FINALIZED:

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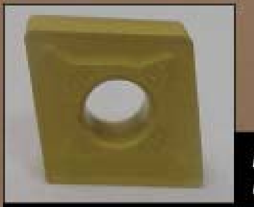

Figure 1: Photograph of cBN-Tin Coating on carbide insert with chip breakers.

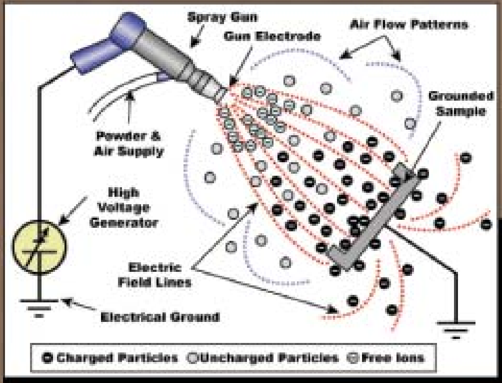

Figure 2: A schematic showing the mechanism of electrostatic spray coating.

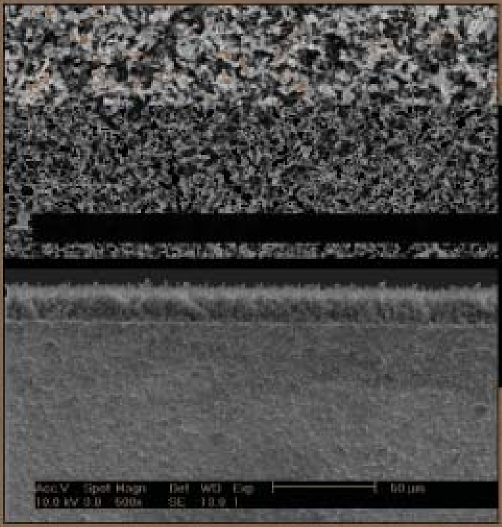

Figure 3: SEM images showing

(A) surface morphology

and

B) cross section profile of a cBN coating preform

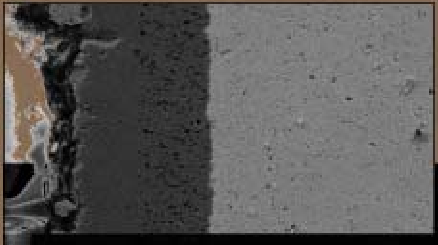

Figure 4: SEM image showing a cross section of the composite coating.

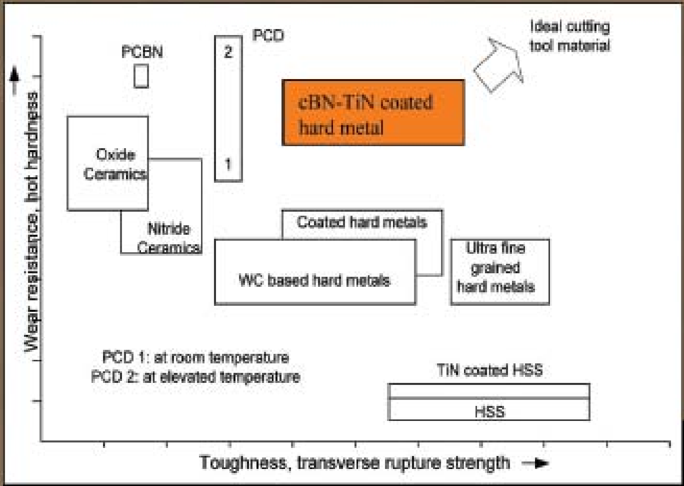

Figure 5: Properties of cutting tool materias [12]

and medium-lot size workpieces of hardened steel. Unlike conventional turning processes, hard turning has very stringent requirements for tool rigidity and wear resistance due to the significantly higher hardness (>45 HRC) of the workpieces.

NEW GENERATION OF SUPERHARD CUTTING MATERIALS DEVELOPED

Advances in technology have made it possible to develop a new generation of superhard materials based on diamond and cubic boron nitride (cBN). These materials have very high hardness and wear resistance and are now regularly used for machining highly abrasive non-ferrous and composite materials, and for hardened ferrous (i.e. iron based) alloys, respectively. Diamond is the hardest material known and has been used in cutting tools for a long time, but because of its aggressive reaction with iron, it cannot be used for cutting ferrous alloys. A complementary material to diamond is cBN, which has excellent thermal stability and chemical inertness against iron. Due to its outstanding physical properties and potential applications, cBN has attracted a great deal of attention in the cutting tool industry. Polycrystalline cubic boron nitride (PCBN) tools, synthesized using high-pressure, high-temperature (HT-HP) process from cBN crystals, have been proven to perform well in the machining of hardened steels and creep resistant alloys. PCBN tools are, however, for the moment both very expensive and brittle. Additionally, PCBN compacts cannot be fabricated in complex geometries such as chip-breaker cutting tools and rotary tools. cBN coated tools potentially offer a solution to both the cost and brittleness, and tool geometry problems which is why cBN coatings have long been the subject of substantial research. However, cBN hard coating have previously remained far from realization due to the poor success achieved in cBN thin film synthesis with the state-of-the-art vapor deposition techniques (which includes both physical and chemical vapor depositions and hybrid techniques involving a combination of these two techniques). Thus, the realization of cBN-coated tools represents a significant advance in the development of improved cutting tools.

CBN-BASED COMPOSITE COATING HAS BEEN DEVELOPED

Based on initial feasibility studies on the synthesis of cBN-TiN hard coatings for turning applications carried out at the Materials and Manufacturing Research Laboratories (MRL) at the University of Arkansas, Fayetteville, and NanoMech, a thick (5~20 _m) cBN-based composite coating, has been developed for cutting inserts including flat, chip-breaker, and rotary tools specifically for turning hardened steels. Figure 1 shows a cBN-TiN coating on a carbide insert with chip breakers.

The cBN-TiN composite coating is synthesized in sequential steps starting with the deposition of a porous cBN particle coating preform (with particle size less than 2 µm) using electrostatic spray coating (ESC), and followed by chemical vapor infiltration (CVI) of titanium nitride (TiN) as a binder. ESC deposition involves in the physical spray of micro- and nano-size particles. The particles are charged at the exit of the spray gun and exposed to an electric field generated by a pointed electrode, as shown schematically in Figure 2. Since powder particles are generally electrically insulating in nature and can carry their static charge over a certain distance, the charged particles follow the electrostatic field lines toward the grounded substrate and form a

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uniform coating. The typical surface morphology and cross section profile of a cBN coating preform are illustrated in Figure 3. In the ESC process, important process parameters that affect the coating formation include the physical properties of the powder (particle density, particle shape, average particle size, particle size distribution, and electrical resistivity), electrode to substrate distance, electrical voltage applied at the electrode, and main air pressure. ESC is a widely used process in the painting industry and can be easily scaled up for batch production. For the deposition on cutting inserts, graphite trays that are typically used in chemical vapor deposition can be readily integrated to facilitate the insert transfer from deposition unit to the subsequent chemical vapor infiltration (CVI) reactor. The CVI process is essentially used for consolidating and binding the porous coating preform to the insert substrate, and operates using the same facility and principles as the chemical vapor deposition (CVD) process, which is controlled either by mass transport kinetics in the gas phase or surface reaction kinetic at the substrate. In the case of TiN, the overall reaction can be written as:

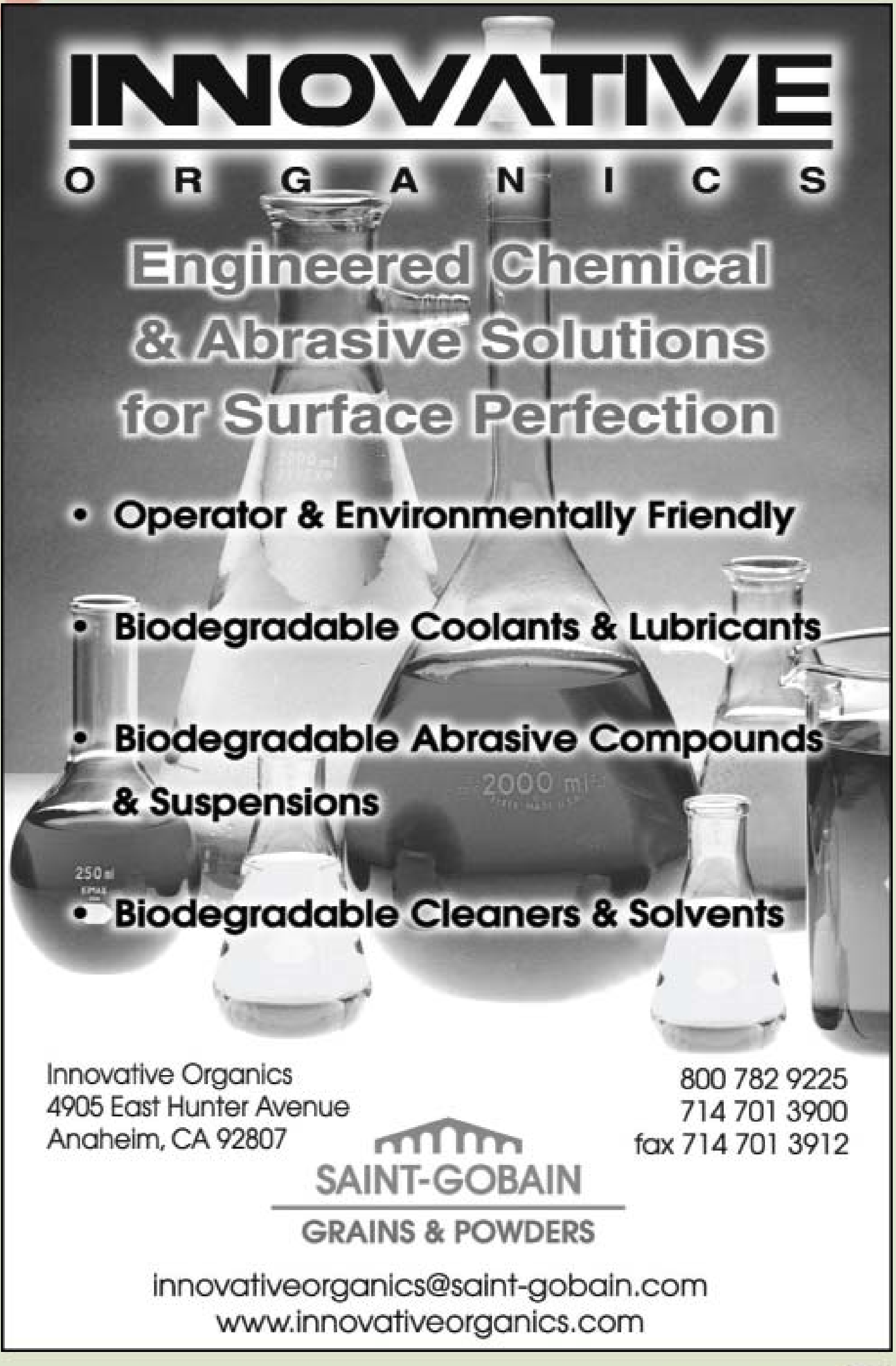
$2TiCl_4+4H_2+N_2 \rightarrow 2TiN+8HCl$

CHEMICAL VAPOR DEPOSITION CBN-TIN PROCESS

For CVD on a regular tool substrate, it is desirable to achieve a rapid deposition rate for productivity. However, for a substrate containing a porous surface coating such as cBN particles deposited using ESC, it is critical to ensure complete infiltration of the porous bed by the precursor gases by slowing down the conversion rate of TiCl4 to TiN. The control of this conversion rate is typically achieved by adjusting the partial pressure of the product gas, HCl. Figure 4 shows a cross section of the composite coating after the infiltration of TiN, which has uniform coating thickness with cBN particles uniformly distributed in the coating. The cBN-TiN composite coating offers a unique combination of hardness and toughness at a cost comparable to conventional tool coatings, as shown in Figure 5. The coating process has essentially evolved from painting and chemical vapor deposition processes, and can be scaled up for full production with minimum modification of the facility and process. The coating can be applied to cutting inserts with various geometries including chip breakers and rotary tools, and provides significant improvement in cutting tool selection, productivity, and application range where PCBN tools simply do not exist. Additionally, cBN-TiN coated inserts are much cheaper than PCBN compact or tipped inserts. The cBN-TiN coated tools can be used for machining ferrous materials, for which polycrystalline diamond (PCD) tools are typically not suitable due to diffusion problems experienced with PCD.

NEW COATING EXCELLENT FOR MACHINING

Machining test has shown excellent performance of the new coating in hard turning applications. For example, cBN-TiN coated inserts (CNMA 432) were tested in finish turning of AISI 4340 hardened steel bars (hardness: 50~52 HRC, diameter=63.5mm, length=381mm) on a CNC lathe (Leblond Makino Baron 60) at a series of machining conditions with surface speed (V) of 100~150m/min (328~492SFM), feed rate (F) of 0.1~0.2mm/rev (0.004~0.008 in/rev), and depth of cut (DoC) of 0.25mm (0.01"). The coated inserts provided smooth cutting with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consistent tool performance and very good workpiece surface finish (less than 1.6 µm). The cBN-TiN coated inserts (CNMA 432) were tested and compared to commonly used PCBN inserts (CNMA 432) and TiAlN coated inserts (CNMA 432) at machining conditions within this range. The comparison of their machining performance is shown in Figure 6. For the case of comparing cBN-TiN coated inserts to PCBN inserts, cBN-TiN coated inserts produced 18 minutes per edge, and PCBN tools produced 32 minutes per edge at which the flank wear is still lower than 0.2 mm and the surface finish started to deteriorate [Figure 6(A)]. For the comparison between cBN-TiN and TiAlN coated inserts, cBN-TiN coated inserts produced significant longer tool life than that of TiAlN coated inserts [Figure 6(B)], and demonstrated superb tool performance in turning hardened steel. Characterization of the tool wear indicated that abrasive wear dominates the tool failure process. A typical picture of the worn surface of a cBN-TiN coated insert is illustrated in Figure 7.

HIGHER PRODUCTIVITY IN A VARIETY OF TOOL GEOMETRIES

NanoMech's new coating process allows development of high-performance coatings for cutting tools with a variety of geometries. The coated inserts have demonstrated superb performance in comparison to a conventional TiAlN coating. The cost of the coating is close to that of conventional cutting tool coatings, yet it can achieve much higher productivity in terms of parts produced per unit time. The coating and the coating process can be used in many different applications areas beyond hard turning, including high-speed mold and die milling, cast iron milling and turning, sintered metal machining, and biometals. ■

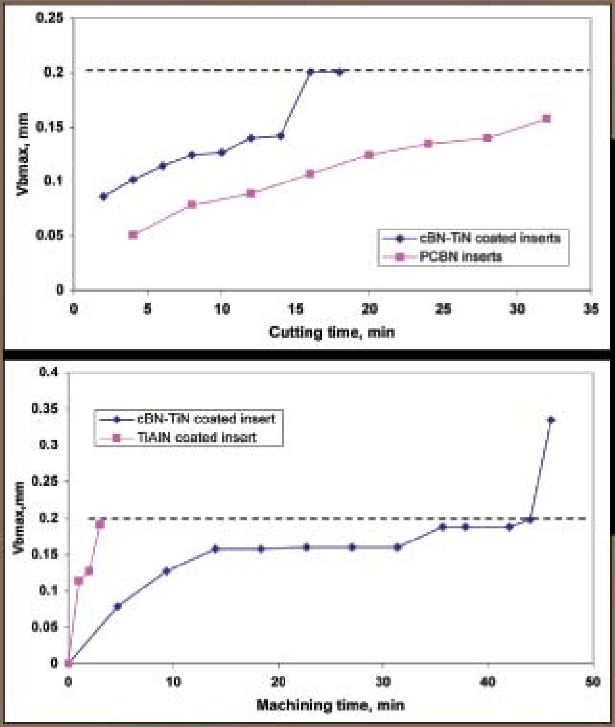

Figure 6: Plot showing performance comparison

(A) cBN-TiN coated and PCBN inserts (CNMA 432, V=125m/min, F=0.15mm/rev, DoC=0.25mm),

and

(B) cBN-TiN and TiAlN coated inserts (CNMA 432, V=150m/min, F=0.15mm/rev, DoC=0.25mm)/

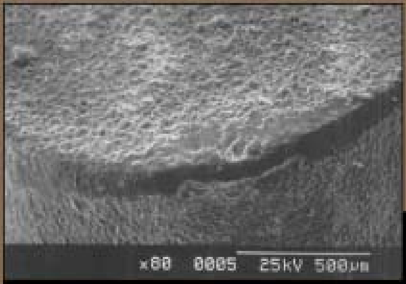

Figure 7: SEM image showing a typical wear pattern on cBN-TiN coated insert.

CHECKLIST

— *of things to do...*

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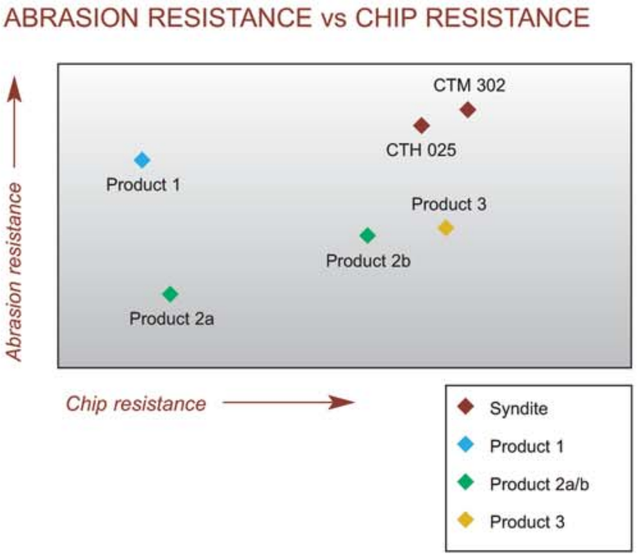

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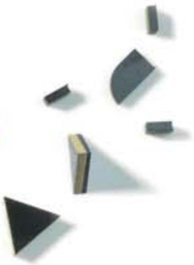

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